NEWS

Chemical industry earnings take worst beating yet Page 20

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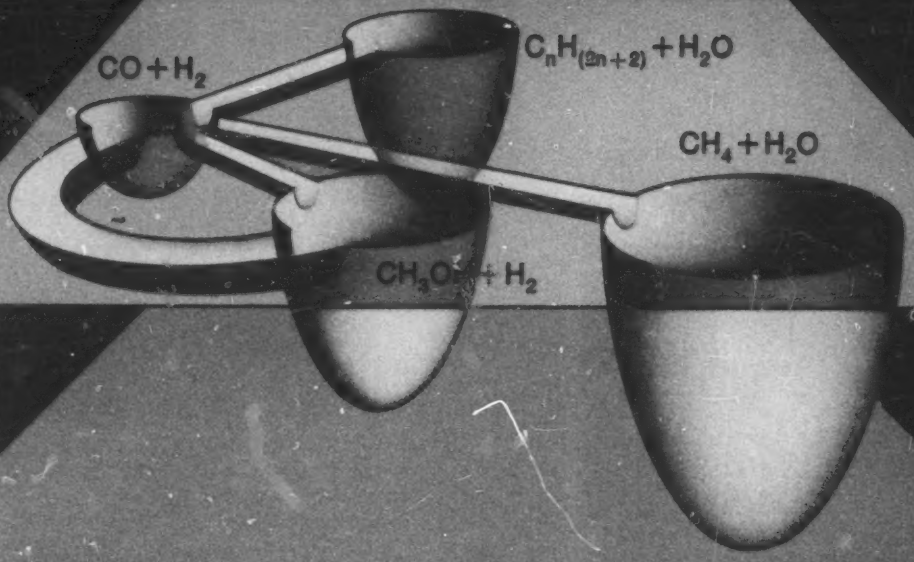

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Industrial Catalysis

Selectivity by design Page 11

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Chemical & Engineering NEWS

Cover: Potential-energy surface for Fischer-Tropsch system indicating that a selective catalyst can provide a path to a particular reaction product

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News of the Week

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- ***More conflict arises over agent orange;*** *NRC recommends delaying a study of the herbicide's effects on American ground troops in Vietnam.* ***Page 7***
- ***International mobility of scientists and engineers*** *declined over the past decade, due in part to dwindling science budgets and increasing costs.* ***Page 7***
- ***Benzo[a]pyrene's potential to cause breast cancer*** *in humans may have been proven by research using a new method to culture pure mammary epithelial cells.* ***Page 8***
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News Focus

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Third-quarter earnings drop is worst yet

Profits at major chemical firms plunged 37% and sales fell 9%; earnings also were down at petroleum and diversified companies

William J. Storck, C&EN New York, and William F. Faliwell, C&EN Washington

In every recession there is a quarter that must be the worst—a three-month period that makes observers sometimes wonder if the industry will ever recover. Chemical industry executives undoubtedly are hoping that the third quarter of 1982 was that sort of pit.

Unfortunately, the fourth quarter, seasonally weak even in good years, is not going well and likely will hand the industry another earnings setback. However, a fourth-quarter drop may be less severe, since profits fell fast in fourth-quarter 1981. At the moment, business is tilting only slightly further down, and some important product lines are trying an upward counter-attack in prices.

Add to these price moves six months of highly encouraging trends in pace-setting financial markets such as stocks and bonds, and you get a consensus among industry spokesmen that recovery seems definitely in view in early 1983. Still, the universal word is caution on just how fast any recovery will proceed.

So for 1982 as a whole, it looks as if the basic chemical industry will have earnings down more than 30%, sales down about 7%, and profit margins on sales down to about 4.1%.

For the period companies have just reported, third-quarter earnings drops affected all types of U.S. chemical producers—basic chemical, diversified, and especially oil companies whose earnings from petrochemical operations were wiped out. Only a pickup in refining economics saved the oil companies' overall results.

For C&EN's core survey of 40 major basic chemical companies, earnings for the third quarter dropped 37% from last year. This, combined with the cumulative 34% drop through the first half, means that the year's earnings thus far are down 35%. At this rate, it would take a miracle to keep earnings from plunging more than a third for the whole year.

Chemical industry leaders for third-quarter . . .

Sales

Rank	$ Millions	Rank 1981
1 Dow Chemical	$2548.0	1
2 Union Carbide	2164.1	2
3 Allied	1514.0	5
4 Monsanto	1504.5	3
5 W. R. Grace	1441.9	4
6 FMC	863.0	9
7 American Cyanamid	861.2	7
8 PPG Industries	840.0	8
9 B. F. Goodrich	795.4	10
10 Celanese	714.0	6

Earnings[a]

	$ Millions	Rank 1981
Allied	$81.0	3
Monsanto	71.0	5
Union Carbide	60.5	1
W. R. Grace	44.4	4
PPG Industries	43.7	6
Dow Chemical	35.0	2
Freeport-McMoRan	34.3	8
Air Products	29.7	14
FMC	29.0	9
American Cyanamid	27.1	6

Profitability

	Earnings as % of sales	Rank 1981
Freeport-McMoRan	18.4%	1
Nalco Chemical	11.0	4
First Mississippi	10.2	2
Lawter International	10.1	3
Petrolite	9.2	10
Great Lakes Chemical	8.0	5
International Minerals	6.8	9
Loctite	6.8	8
Chemed	6.1	11
Lubrizol	6.0	5

. . . and for first nine months 1982

Sales

Rank	$ Millions	Rank 1981
1 Dow Chemical	$8057.0	1
2 Union Carbide	6775.6	2
3 Monsanto	4859.6	3
4 Allied	4723.0	5
5 W. R. Grace	4535.3	4
6 FMC	2612.4	9
7 American Cyanamid	2607.8	7
8 PPG Industries	2470.0	8
9 Celanese	2352.0	6
10 B. F. Goodrich	2300.0	10

Earnings[a]

	$ Millions	Rank 1981
Monsanto	$304.7	3
Union Carbide	269.5	1
Allied	226.0	4
Dow Chemical	209.0	2
W. R. Grace	200.4	5
PPG Industries	113.5	6
Stauffer Chemical	113.4	9
FMC	106.7	10
American Cyanamid	90.3	7
Freeport-McMoRan	83.4	8

Profitability

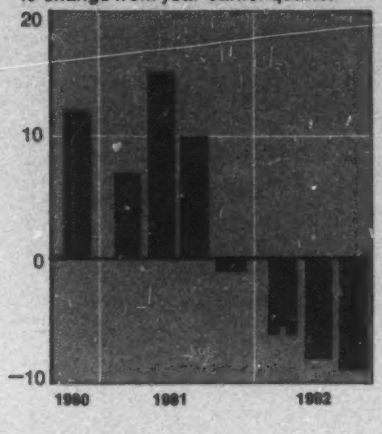
	Earnings as % of sales	Rank 1981
Freeport-McMoRan	15.0%	1
Nalco Chemical	10.2	3
Petrolite	9.8	8
Stauffer Chemical	9.3	7
Lawter International	9.0	5
Great Lakes Chemical	8.4	2
Air Products	7.0	11
Chemed	6.9	9
Lubrizol	6.7	6
Liquid Air	6.4	12

a After taxes. Note: For 40 chemical companies listed on page 22.

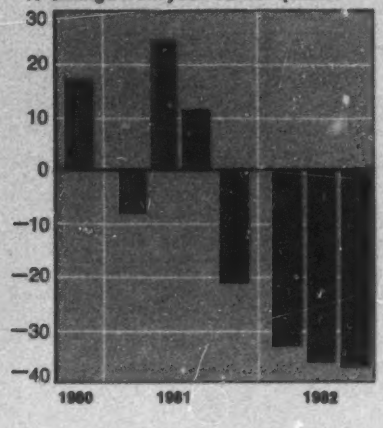
Chemical Industry Third-Quarter Results

- Sales fell 9%
- Earnings plunged 37%
- Profitability fell to 3.5%
- Production sank 11%
- Prices dropped 0.4%

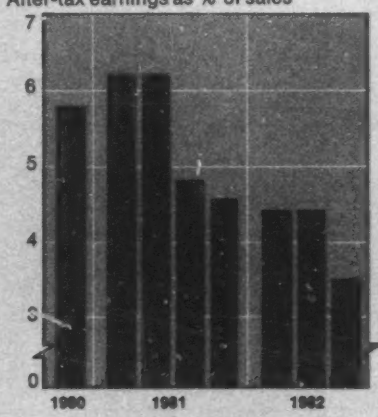
Sales
% change from year-earlier quarter



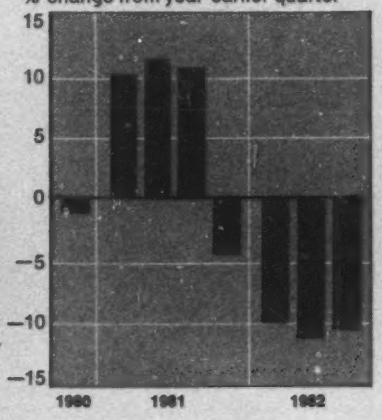
Earnings
% change from year-earlier quarter



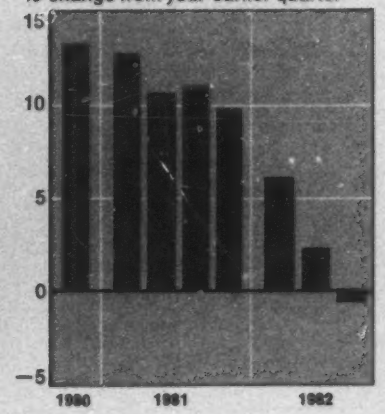
Profit margins
After-tax earnings as % of sales



Production
% change from year-earlier quarter

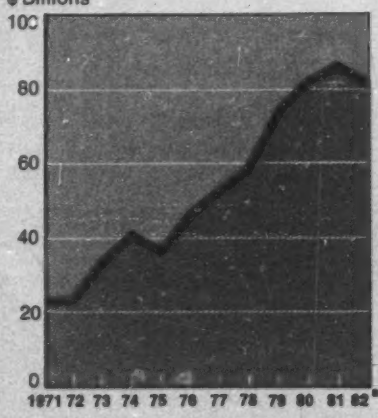


Prices
% change from year-earlier quarter

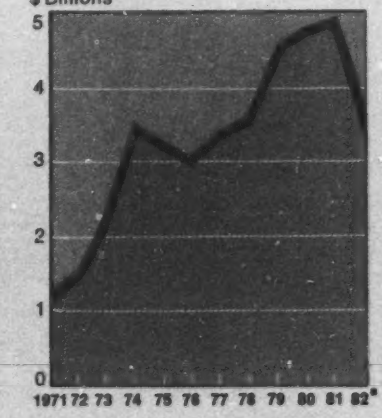


Sales in 1982 will fall about 7%, and earnings will drop more than 30%, sending profitability down to about 4.1%

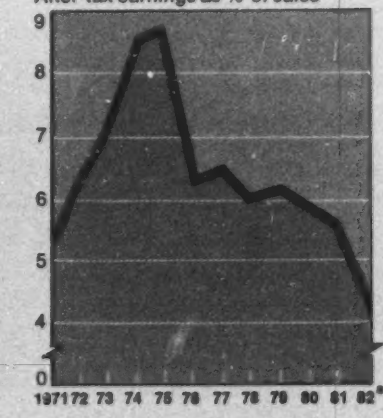
Annual sales
$ Billions



Annual earnings
$ Billions



Annual profit margins
After-tax earnings as % of sales



*C&EN estimates. **Note:** All sales, earnings, and profit-margin data are based on the combined performance of the 40 largest chemical makers listed on page 22.

Third-quarter chemical earnings at chemical companies fell 37% as profit margins plunged

	THIRD-QUARTER 1982						NINE-MONTHS 1982			
	Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales	Change from 1981 Earnings	Profit margin[a] 1982	Profit margin[a] 1981	Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales	Change from 1981 Earnings
Dow Chemical[d]	$ 2,548.0	$ 35.0	−13%	−73%	1.4%	4.4%	$ 8,057.0	$ 209.0	−9%	−56%
Union Carbide[e]	2,164.1	60.5	−11	−61	2.8	6.4	6,775.6	269.5	−13	−47
Allied[f]	1,514.0	81.0	−2	1	5.4	5.2	4,723.0	226.0	0	−10
Monsanto[g]	1,504.5	71.0	−8	27	4.7	3.4	4,859.6	304.7	−10	−6
W. R. Grace[h]	1,441.9	44.4	−9	−31	3.1	4.0	4,535.3	200.4	−5	−19
FMC	863.0	29.0	2	−29	3.4	4.6	2,612.4	106.7	5	−13
American Cyanamid[i]	861.2	27.1	−8	−48	3.1	5.6	2,607.8	90.3	−4	−39
PPG Industries	840.0	43.7	−1	−16	5.2	6.2	2,470.0	113.5	−3	−34
B. F. Goodrich[j]	795.4	−0.1	−3	def	def	1.8	2,300.0	−3.5	4	def
Celanese	714.0	−18.0	−25	def	def	3.5	2,352.0	20.0	−18	−82
Hercules[k]	602.0	25.6	−13	−29	4.3	5.2	1,890.0	69.8	−9	−42
National Distillers	448.4	15.5	−7	−49	3.5	6.3	1,377.7	61.9	−9	−38
Rohm & Haas[l]	441.3	17.2	−1	−20	3.9	4.8	1,444.6	61.2	−2	−26
Olin	433.9	11.2	−11	−37	2.6	3.6	1,407.8	56.6	−10	−28
Air Products[m]	415.6	29.7	3	3	6.5	6.5	1,195.4	83.2	−1	−11
Ethyl	410.7	23.0	−8	8	5.6	4.7	1,231.0	68.0	−7	1
Williams Cos.	380.6	−0.3	−21	def	def	2.9	1,332.4	25.0	−14	−72
International Minerals	356.5	24.4	−12	−32	6.8	8.9	1,176.4	52.6	−19	−55
Witco Chemical[n]	331.8	8.6	2	−10	2.6	2.9	1,001.7	21.5	2	−22
Stauffer Chemical[o]	283.6	14.1	−17	−1	5.0	4.2	1,219.5	113.4	−10	−10
Pennwalt	232.4	7.3	−10	−46	3.1	5.3	732.8	24.5	−9	−38
Lubrizol	199.0	11.9	−10	−50	6.0	10.8	615.7	41.1	−9	−45
Reichhold Chemicals	197.4	1.1	−20	−71	0.6	1.6	630.2	8.2	−15	−47
Morton Thiokol[p]	193.5	14.5	1	—	7.5	—	652.3	41.4	5	—
Freeport-McMoRan	186.1	34.3	−8	−23	18.4	21.8	556.1	83.4	−13	−37
GAF[q]	179.2	6.8	1	def	4.9	def	482.1	−1.3	−9	def
Nalco Chemical	160.1	17.6	−5	−17	11.0	12.6	485.0	49.4	−1	−18
International Flavors[r]	—	—	—	—	—	10.1	—	—	—	—
Liquid Air	115.2	6.0	10	−16	5.2	6.8	339.0	21.6	5	−10
H. B. Fuller	79.6	2.5	−5	−34	3.1	4.6	235.2	6.6	−5	−36
Petrolite	73.6	6.8	−1	21	9.2	7.5	230.9	22.6	5	12
Chemed[s]	64.2	3.9	−1	−19	6.1	7.4	188.9	13.1	1	−15
Stepan Chemical	54.3	1.7	8	22	3.1	2.8	160.8	4.2	3	−6
Loctite	53.1	3.6	−3	−29	6.8	9.4	162.3	10.1	−3	6
Crompton & Knowles	52.3	0.6	−14	−61	1.2	2.7	162.3	2.7	−13	−54
First Mississippi	49.2	5.0	14	−27	10.2	15.8	163.0	9.7	−11	−25
Great Lakes Chemical	43.9	3.5	8	−21	8.0	10.8	126.7	10.7	15	−26
Essex Chemical[t]	40.3	1.5	−1	−36	3.7	5.6	125.2	5.5	−6	−4
Philip A. Hunt	29.4	1.0	7	−41	3.4	6.2	89.2	5.0	9	9
Lawter International	19.8	2.0	−7	−31	10.1	13.6	60.3	5.4	−8	−27
Total 20 largest companies	$17,350.5	$542.6	−8.8%	−40.2%	3.1%	4.9%	$54,569.2	$2149.8	−7.5%	−35.2%
Total 18 other companies[u]	$ 1,829.1	$119.1	−7.0%	−20.2%	6.5%	7.6%	$ 5,545.7	$ 322.5	−6.5%	−30.0%
GRAND TOTAL[u]	$19,179.6	$661.7	−8.7%	−37.4%	3.5%	5.0%	$60,114.9	$2472.3	−7.4%	−34.6%

a After-tax income as a percentage of sales. b Fully diluted before nonrecurring and extraordinary items. c As of Oct. 29. d Excludes $177 million extraordinary and nonrecurring gains in nine months 1982 and $20 million nonrecurring gain in nine months 1981. e Excludes $10 million nonrecurring gain in third quarter; third-quarter and nine-months 1981 figures are restated for accounting changes. f Excludes $38 million nonrecurring gain in third-quarter 1981. g Excludes $67.7 million nonrecurring gain in third-quarter 1981. h Excludes $33.7 million nonrecurring gain in third-quarter and nine-months 1981 and $65.1 million nonrecurring gain in nine-months 1982. i Excludes $2.9 million nonrecurring gain in third-quarter 1982. j Excludes nonrecurring gain of $8.5 million in third-quarter 1981, $4.4 million in nine-months 1982, and $30.8 million in nine-months 1981. k Excludes $6.2 million nonrecurring gain in third-quarter 1982. l Excludes

In a rare event, annual sales also are dropping, with a fresh decline of 9% in the third quarter. And profitability on sales is falling to its lowest level in decades, not much more than 4.0%.

So a miracle would serve just fine about now, but miracles may be in short supply. The problems grinding on the chemical industry all year are still there, even if their severity is no longer increasing.

Major markets remain depressed. The housing industry, though showing a few signs of upturn, is still in dire trouble. The automobile industry is in a shambles, and even when it begins to recover, it will be bucking imports. The farm economy is not good and could get worse. And fibers continue to battle rising textile imports, while a stronger U.S. dollar and weak foreign economies undermine exports.

12-MONTH RUNNING DATA						Earnings per share[b]		STOCK MARKET DATA[c]					
Profit margin[a]		Change from 1981		Profit margin			Recent	Stock price	Recent 12 months		Price earnings ratio	Annual indicated	Dividend yield, %
1982	1981	Sales	Earnings	1982	1981	3rd qtr	12 months	Oct. 29	High	Low	Oct. 29	dividend	of price
2.8%	5.4%	−11%	−55%	2.7%	5.3%	$0.18	$1.43	$25¾	$28½	$19⅝	18	$1.80	7.0%
4.0	6.5	−12	−36	4.4	6.1	0.88	5.95	54¼	58⅞	40⅛	9	3.40	6.3
4.8	5.3	4	−8	5.0	5.6	1.95	7.62	34¼	48⅜	28¾	4	2.40	7.0
6.3	6.0	−9	−2	5.6	5.2	1.79	9.14	77¼	84⅞	56⅝	8	4.00	5.2
4.4	5.2	−3	−19	4.5	5.4	0.91	6.04	39⅜	46½	28½	7	2.80	7.1
4.1	4.9	5	−6	4.3	4.9	0.81	4.23	31¾	35	23⅛	8	1.80	5.7
3.5	5.5	−1	−19	4.1	5.0	0.56	3.01	33¾	35⅜	24⅜	11	1.75	5.2
4.6	6.7	−2	−35	4.5	6.9	1.27	4.24	48⅛	50¼	29	11	2.36	4.9
def	1.9	−4	−61	0.9	2.3	−0.15	0.98	26¾	27¾	16⅝	27	1.56	5.8
0.9	3.8	−15	−63	1.7	4.0	−1.25	3.06	49⅛	62	41⅝	16	4.00	8.1
3.7	5.8	−6	−5	4.8	4.7	0.58	2.24	26¾	28¾	16⅞	12	1.32	4.9
4.5	6.6	−5	−26	5.4	7.0	0.41	2.91	25¼	28¾	18⅞	9	2.20	8.7
4.2	5.6	−2	−24	4.1	5.3	1.33	5.82	68⅞	71½	45½	12	2.80	4.1
4.0	5.1	−8	−23	3.8	4.5	0.48	2.99	23⅛	24½	15½	8	1.20	5.2
7.0	7.8	0	−9	7.3	8.0	1.03	4.03	32⅜	40¼	23⅝	8	0.80	2.5
5.5	5.0	−6	5	5.7	5.1	1.13	4.53	31½	31½	18⅛	7	1.50	4.8
2.2	6.7	−14	−81	1.4	6.4	0.11	1.17	17⅞	30⅝	12⅝	15	1.20	6.7
4.5	8.0	−18	−49	5.1	8.2	0.92	3.04	32⅞	36	23½	11	2.60	7.9
2.1	2.8	1	−5	2.6	2.8	0.91	3.46	26⅛	27	20⅝	8	1.80	6.9
9.3	9.3	−10	−10	8.6	8.6	0.31	3.13	24	25	17	8	1.44	6.0
3.3	4.9	−18	−26	3.1	3.5	0.70	2.02	34⅜	34⅞	21½	17	2.20	6.4
6.7	11.0	−10	1	9.5	8.5	0.31	1.51	19⅝	26¼	14¼	13	1.08	5.5
1.3	1.8	−13	−36	1.5	2.1	−0.05	0.89	13½	15⅜	10	15	0.48	3.6
6.3	—	—	—	6.1	—	—	—	49⅜	50	27¾	5	1.52	3.1
15.0	21.0	−7	−44	13.0	21.5	0.49	1.54	15¾	28⅛	12¼	10	0.60	3.8
def	0.4	−11	def	def	0.0	0.59	−0.93	12¼	15¼	8⅝	—	0.20	1.6
10.2	12.2	2	−12	10.7	12.3	0.44	2.69	28	29⅜	18	10	1.12	4.0
—	11.7	—	—	—	14.7	—	—	23⅞	27	17⅜	14	1.04	4.4
6.4	7.4	4	0	6.7	6.9	0.46	2.32	19¾	20¾	14½	9	1.60	8.1
2.8	4.2	2	−30	3.1	4.4	0.55	2.13	22⅝	26½	14¼	11	0.52	2.3
9.8	9.1	8	17	9.8	9.1	0.57	2.54	27½	37	19¾	11	1.00	3.6
6.9	8.2	3	−30	6.9	10.3	0.45	1.45	27	31	21⅝	19	1.25	4.6
2.6	3.4	7	5	2.9	2.9	0.48	1.70	12¾	20	9¼	8	0.56	4.4
6.2	5.7	−2	−6	6.6	6.8	0.37	1.42	29¼	30¾	18⅛	21	0.56	1.9
1.7	3.2	−12	−32	2.5	3.2	0.16	1.49	14⅜	18⅛	12⅛	10	1.04	7.2
6.0	7.1	−8	−39	6.1	9.2	0.25	0.77	9⅜	16⅞	6	12	0.24	2.6
8.4	13.1	15	−28	8.6	13.7	0.49	1.99	37⅜	45	24⅞	19	0.56	1.5
4.4	4.3	−4	−16	4.3	4.8	0.51	2.44	20½	20½	15⅞	8	0.80	3.9
5.6	5.6	8	def	3.6	def	0.18	0.73	11⅝	12¼	8⅝	16	0.40	3.4
9.0	11.2	−7	−24	9.9	12.1	0.17	0.69	11¼	12⅜	8⅝	16	0.72	6.4
3.9%	5.6%	−6.5%	−28.9%	4.2%	5.5								
5.8%	7.8%	−6.5%	−26.7%	5.7%	7.3%								
4.1%	5.8%	−6.5%	−28.6%	4.3%	5.6%								

$9.0 million nonrecurring charge in nine-months 1981. m Excludes $9.3 million nonrecurring charge in nine-months 1982. n Excludes $1.0 million nonrecurring charge in third-quarter 1982 and $0.6 million nonrecurring gain in nine-months 1982. o Includes extraordinary item. p Because merger of Morton and Thiokol was not yet complete, Thiokol's earnings were reported on an equity basis making comparisons with prior years meaningless. q Third-quarter 1982 excludes $7.0 million nonrecurring gain. r Not all data available at press time. s Excludes $5.3 million nonrecurring gain in third-quarter 1981. t Excludes $0.9 million nonrecurring gain in nine-months 1981. u Excludes results of Morton Thiokol for purposes of comparison. def = deficit.

As a result, chemical production continues its declines, causing capacity to muddle along at a 63% rate (C&EN, Oct. 11, page 12). And prices for chemicals and allied products, although stabilizing lately, are below their year-ago levels.

This combination is wrecking not only profits at major chemical companies, but also sales. For the first time since 1975, the only previous year in recent decades, sales for the full year for basic chemical companies will be down—probably 7% or more.

The sales and earnings drops in the third quarter were widespread. Of the 40 companies surveyed, earnings for 31, or almost 80%, declined from a year ago. Almost the same number, 29, had sales drops. Earnings' declines for three firms—B. F. Goodrich, Celanese, and Williams Cos.—resulted from deficits.

Total sales for 38 of the 40 com-

Sales and earnings continue down at many petroleum companies

	% chemical sales	THIRD-QUARTER 1982 Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales	Change from 1981 Earnings	Profit margin[a] 1982	Profit margin[a] 1981	NINE-MONTHS 1982 Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales
Exxon	7%	$25,331.0	$1070.0	−8%	0%	4.2%	3.9%	$77,477.0	$3195.0	−9%
Mobil	3	15,534.0	323.0	−7	−36	2.1	3.0	47,727.0	959.0	−5
Texaco[b]	3	11,800.0	411.0	−18	−30	3.5	4.1	36,300.0	1,[illegible]3.0	−19
Standard Oil of California	3	8,666.0	459.0	−24	−13	5.3	4.6	28,056.0	952.0	−19
Standard Oil (Ind.)[b]	8	7,676.0	608.0	−4	15	7.9	6.6	22,399.0	1460.0	−6
Gulf Oil[b]	8	7,538.0	204.0	1	−35	2.7	4.2	22,502.0	720.0	0
Atlantic Richfield	10	6,659.4	446.9	−4	3	6.7	6.2	19,895.4	1242.1	−6
Shell Oil	15	5,098.0	442.0	−9	−6	8.7	8.4	15,037.0	1166.0	−9
Phillips Petroleum	15	4,002.0	131.6	3	−32	3.3	4.9	11,845.0	460.4	−3
Sun Co.[b]	5	3,800.0	152.0	3	−28	4.0	5.7	11,800.0	386.0	2
Tenneco[b]	10	3,674.0	198.0	3	26	5.4	4.4	11,223.0	486.0	1
Standard Oil (Ohio)	3	3,175.0	487.3	−14	3	15.3	12.7	9,387.4	1420.0	−7
Getty Oil	2	3,073.0	178.1	−6	−13	5.8	6.3	9,275.9	493.4	−5
Union Oil[b]	11	2,771.7	212.8	−5	10	7.7	6.6	8,163.0	578.9	−3
Cities Service[b]	3	1,970.7	45.4	2	−42	2.3	4.1	5,933.9	97.1	1
El Paso[b]	15	954.8	26.8	−1	−32	2.8	4.1	2,845.2	66.2	2
Kerr-McGee[b]	14	913.5	56.8	−4	13	6.2	5.3	2,762.0	153.2	0
Internorth[b]	10	806.2	14.5	9	−23	1.8	2.5	2,080.5	143.6	14
American Petrofina	13	540.1	12.7	−12	−41	2.4	3.5	1,723.3	39.6	−13

a After-tax income as percentage of sales. b Excludes major nonrecurring gains or charges to earnings: Texaco—$108 million charge in the third quarter 1982; Standard Oil (Ind.)—$49 million charge in third-quarter 1982 and $80 million gain in third-quarter 1981; Gulf Oil—$56 million charge in third-quarter 1982 and $97 million charge in nine-months 1982; Sun Co.—$135 million gain in second-quarter 1981; Tenneco—$73 million gain in second-quarter 1982; Union Oil—$24.4 million gain in second-quarter 1981; Cities Service—$21.4 million charge in

Petrochemical profits disappeared in third quarter

The long night continues for chemical operations, chiefly petrochemicals, at U.S. oil and natural gas companies. Making up one sales dollar out of every four in U.S. chemicals—the biggest block outside the basic chemical industry—these operations as a group lost all profitability in the third quarter.

Third-quarter chemical earnings came to a slight combined loss at five leading oil companies reporting after-tax data. That's by far the worst decline yet in petrochemicals' extended private recession, which has run without letup, in terms of earnings drops, since third-quarter 1980.

It was a lucky oil or gas company that could use black ink for chemicals in the third quarter. Losses stud the list. At Shell Oil, which lost $15 million in chemicals in the third quarter, president John F. Bookout comments, "The improvement in chemicals we hoped for six months ago has not materialized. If anything, demand and prices continued to weaken during the summer."

This means that chemicals are running counter to a considerably improved performance in Shell's oil products segment (refining, transportation, and marketing). Record profits here helped Shell hold its overall profits drop to just 6% and keep its profit margin on sales at a very respectable 8.7%. Other oil companies echo Shell's report of a pickup in refining operations, and some sport a similar improved overall profit margin.

So chemicals stand out worse than ever in oil companies' results. In the worst case, Gulf Oil gave up on several of its specialty chemical units (mainly at acquired Millmaster Onyx) and wrote them off for more than $100 million (pretax). This move gave Gulf an operating loss of $144 million pretax on its U.S. chemical operations in the third quarter and $194 million for the nine months. In 1981, these chemicals were marginally profitable in the third quarter and lost $22 million in the first nine months.

The largest petrochemical producers barely made money in the third quarter. At Exxon, the largest producer, chemical profits sank 75% from a year ago to just $16 million on sales (including intracompany transfers) of $1.71 billion. Sales in dollars fell 14% in the third quarter and 15% in the first nine months from 1981. In volume, nine-month sales were off 10% in the U.S. and 7% abroad.

Smaller chemical operations had a rougher time. Mobil's $518 million in chemical sales eked out $3 million in profits in the third quarter. Standard Oil (Ind.) about broke even on its chemical sales of $585 million.

	AFTER-TAX EARNINGS Third quarter			Nine months		
$ Millions	1982	1981	% change	1982	1981	% change
Exxon	$16.0	$ 65.0	−75%	$ 83.0	$222.0	−63%
Mobil	3.0	17.0	−82	38.0	70.0	−53
Shell Oil	−15.0	14.0	def	1.0	35.0	−97
Standard Oil (Ind.)	0.0	19.0	−100	83.0[a]	110.0	−25
Texaco	−5.0	13.0	def	16.0	62.0	−76
TOTAL	$−1.0	$128.0	def	$216.0	$499.0	−57%

a Includes nonrecurring gain of $19 million. Def = deficit.

NINE-MONTHS 1982			STOCK MARKET DATA							
Change from 1981	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio	Annual indicated dividend	Dividend yield, % of price
				Recent		Recent 12 months				
Earnings	1982	1981	3rd qtr	12 months	Oct. 29	High	Low	Oct. 29		
−29%	4.1%	5.3%	$1.23	$4.90	$29⅝	$33⅛	$24⅞	6	$3.00	10.1%
−48	2.0	3.7	0.78	3.68	25	28⅝	19½	7	2.00	8.0
−40	3.0	4.0	1.57	6.11	30⅝	35⅛	26	5	3.00	9.8
−47	3.4	5.3	1.34	4.45	30¼	46	23½	7	2.40	7.9
0	6.5	6.1	2.09	6.29	41⅛	55¾	33½	7	2.80	6.8
−23	3.2	4.1	1.15	5.34	28½	38½	24¼	5	2.80	9.8
3	6.2	5.7	1.76	6.77	42½	50⅜	32¼	6	2.40	5.6
−6	7.8	7.5	1.43	5.27	38¼	46⅞	27⅛	7	1.80	4.7
−34	3.9	5.7	0.86	4.25	31¼	45⅞	23½	7	2.20	7.0
−22	3.3	5.4	1.25	4.36	32½	48¾	26¾	7	2.30	7.1
−12	4.3	5.0	1.38	5.31	33⅛	34⅞	22⅞	6	2.72	8.2
−3	15.1	14.5	1.97	7.68	36⅝	46¼	26½	5	2.60	7.1
−23	5.3	6.5	2.23	8.74	56	70½	41¼	6	2.60	4.6
9	7.1	6.3	1.22	4.69	27⅞	42⅝	21¼	6	1.00	3.6
−57	1.6	3.8	0.61	2.77	48¼	56⅜	23¾	17	1.60	3.3
−39	2.3	3.9	0.54	2.16	17	28⅛	13⅝	8	1.48	8.7
6	5.5	5.3	1.08	4.19	30⅞	42¼	22½	7	1.10	3.6
−18	4.8	6.7	0.32	4.73	28⅛	32¼	21	6	2.12	7.5
−31	2.3	2.9	1.17	5.24	55¾	63⅜	41½	11	3.20	5.7

third-quarter 1982 and $45.5 million gain in nine-months 1982; El Paso—$5.9 million gain in third-quarter 1982; Kerr-McGee—$17.0 million charge in second-quarter 1982; Internorth—$9.5 million gain in third-quarter 1981.

panies, that had reported by press time and had comparable year-to-year data, in the third quarter dropped 8.7% to $19.2 billion from the same period of 1981. (The year-to-year comparisons do not include Morton Thiokol. Earnings at this company are not comparable to those of a year ago. The acquisition of Thiokol was as yet incomplete at the end of the third quarter, and earnings from Thiokol are reported on an equity basis. Since prior years have not been restated, comparisons of the results between the two years is not yet meaningful.)

Combined earnings for the quarter took a big drop to $1.62 billion, down 37% from last year's level. This is the biggest drop in earnings in the current recession, beating the second quarter's year-to-year decline of 36%.

As in the past, the larger, more commodity-oriented chemical companies performed worse than did the smaller firms in the third quarter. Among the 20 larger firms, combined sales dropped 8.8% from third-quarter 1981 to $17.4 billion. Earnings among the top group fell 40.2% to $543 million.

Earnings among this group were dragged down by some huge drops at some larger firms. Dow Chemical, the largest company on the list, posted an earnings decrease of 73% from last year's third quarter to $35.0 million. Union Carbide's earnings fell 61% to $61 million. (The third-quarter 1981 figure for Union Carbide has been restated to reflect an accounting change, making the two years comparable. Carbide's actual third-quarter 1981 earnings were considerably lower, $138 million.)

Of the 20 larger companies surveyed, seven, including the three with losses, recorded earnings drops greater than the 40.2% average. Without these seven companies, earnings among the remaining 13 firms were down just 11.6% from a year ago.

There were not such big differences in sales, however. Except for a couple of big declines—25% at Celanese and 21% at Williams Cos.—most sales declines were close to the average. Countering the large declines, sales gained a little at three companies—FMC, Air Products, and Witco Chemical.

Profit margins (earnings as a percentage of sales) at the 20 larger firms continued their slide in the third quarter. The average profit margin for the group was 3.1%, compared to 4.8% in third-quarter 1981.

For the first nine months of 1982, the profit margin decline is not so bad. But it is bad enough to foretell the lowest full-year profitability since World War II. Specifically, for the first nine months, earnings among the 38 companies used to figure the average declined 35% to $2.47 billion from the first three quarters of 1981. Sales for the group dropped 7.4% to $60.1 billion. As a result, profit margins for the chemical companies fell to 4.1% from 5.8% in the same period of 1981.

Once again the larger firms had the larger fall in the year's first three quarters. Total earnings of the 20 bigger companies fell an average of 35% from the first nine months of 1981 to $2.15 billion. Sales dropped 7.5% to $54.6 billion. As a result the average profit margin for the group dropped to 3.9% from 5.6% in the first three quarters last year.

Among the smaller firms, combined earnings dropped an average of 30% during the first three quarters to $323 million. Total sales for the group fell 6.5% to $5.55 billion, driving profit margins down to 5.8% from 7.8% in the first nine months of 1981.

The third quarter spared hardly any major product group. A good example comes from Celanese, where

Earnings damage was heavy at many diversified chemical producers

	% chemical sales	THIRD-QUARTER 1982 Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales	Change from 1981 Earnings	Profit margin[a] 1982	Profit margin[a] 1981	NINE-MONTHS 1982 Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales
Du Pont	31%	$8202.0	$195.0	−1%	−29%	2.4%	3.3%	$24,963.0	$ 692.0	2%
General Electric	4	6390.0	451.0	−4	11	7.1	6.1	19,040.0	1293.0	−3
U.S. Steel[b]	10	4522.8	−82.4	30	def	def	15.5	14,625.6	1.8	37
Procter & Gamble	4	3201.0	257.0	6	15	8.0	7.4	9,274.0	620.0	6
Eastman Kodak	19	2542.1	303.9	0	−9	12.0	13.1	7,220.2	733.5	−1
Dart & Kraft[c]	11	2496.3	106.8	−3	16	4.3	3.6	7,433.4	304.8	−2
Beatrice Foods[c]	5	2334.8	84.3	1	2	3.6	3.6	6,840.0	229.6	1
Goodyear Tire & Rubber[b,c]	12	2160.0	89.0	−6	29	4.1	3.0	6,600.0	197.9	−4
3M	15	1691.0	169.2	0	−1	10.0	10.2	5,044.0	480.3	2
Georgia-Pacific[b,c]	14	1422.0	−1.0	1	def	def	2.2	4,036.0	95.0	−4
Aluminum Co. of America[c]	11	1145.2	−11.6	−11	def	def	5.6	3,590.5	27.4	−8
Borden[c]	32	1058.1	43.0	−3	−5	4.1	4.1	3,025.3	92.3	−10
Pfizer	14	909.6	71.5	11	23	7.9	7.1	2,593.3	240.3	7
Martin Marietta	14	892.0	38.0	7	−37	4.3	7.2	2,586.2	94.0	6
Borg-Warner	24	809.3	36.1	5	−15	4.5	5.5	2,390.6	119.1	2
Esmark	18	779.1	20.8	−4	−24	2.7	3.4	2,318.9	62.5	2
Diamond Shamrock[c]	34	773.2	42.3	−6	−22	5.5	6.6	2,422.0	103.3	−3
Merck	23	753.4	94.5	6	10	12.5	12.3	2,271.6	315.6	5
Kaiser Aluminum[b]	17	696.3	63.3	−11	414	9.1	1.6	2,245.0	8.4	−10
Eli Lilly[c]	18	670.9	98.7	8	14	14.7	13.9	2,242.3	312.3	9
Engelhard[c]	11	533.2	17.1	6	−4	3.2	3.5	1,416.5	47.6	−14
General Tire[c]	19	509.4	29.0	−10	−2	5.7	5.2	1,551.7	54.7	−5
NL Industries[c]	23	500.4	34.0	−17	−61	6.8	13.5	1,798.1	200.6	0
Koppers	34	479.4	19.1	−11	−24	4.0	4.7	1,278.1	16.0	−15
Uniroyal[c]	28	471.2	4.3	−12	−65	0.9	2.3	1,497.3	13.6	−12
Northwest Industries	6	451.4	6.7	−45	−90	1.5	7.8	1,917.3	178.0	−17
Upjohn	17	430.0	20.1	−4	−41	4.7	7.6	1,366.1	101.4	−5
Emhart	16	400.8	17.7	0	−19	4.4	5.5	1,309.5	56.0	2
Tyler	36	225.0	4.3	6	−66	1.9	5.9	654.0	7.7	21
Vulcan Materials	34	198.3	18.0	−7	−25	9.1	11.2	550.3	46.5	−6

a After-tax income as percentage of sales. b Earnings include major nonrecurring items. c Excludes major nonrecurring gains or charges in earnings: Dart & Kraft—$75.8 million net charge in third-quarter 1982, $11.6 million net gain in third-quarter 1981, $71.6 million net charge in nine-months 1982, and $59.5 million net gain in nine-months 1981; Beatrice Foods—$31.9 million gain in second-quarter 1982 (first fiscal quarter 1983) and $45.1 million gain in third-quarter 1981 (second fiscal quarter 1982); Goodyear—$17.2 million gain in second-quarter 1982; Georgia-Pacific—$27.0 million gain in third-quarter 1982 and $130 million gain in first-quarter 1982; Aluminum Co. of America—$2.8 million charge in third-quarter 1982, $19.9

every business segment turned down and all but two showed losses. In the third quarter in domestic businesses, the company's plastics and specialties operations turned in a net loss of 27 cents a share, compared with net income of 29 cents a share in the same period last year. The chemicals group lost 12 cents a share compared to earnings of 74 cents a share last year. Its fibers operation was the only one to show a profit in the U.S., but even here net income dropped to 28 cents a share from $1.00 per share in the third quarter last year. Third-quarter 1982 profits all came in cellulosics, which earned 29 cents a share.

The profit in Celanese's fibers, however, was more than offset by losses in the company's overseas fibers operations. Here the red ink ran to 80 cents a share, compared with a loss of 26 cents a share in third-quarter 1981. Overseas plastics and specialties showed a profit of 6 cents a share, down slightly from last year's 7 cents a share.

There are a few signs that things may be getting a little better in plastics, if for no other reason than the effects of cost cutting and shutting down unprofitable operations.

At Monsanto, operating (pretax) profit for plastics and resins increased to $12 million in the third quarter from a loss of $2.6 million in the same period last year. Sales of plastics and resins at the company, however, dropped to $307 million, a 10.5% decline from third-quarter 1981.

At Allied Corp., income from fibers and plastics increased 19% in the third quarter to $32 million. But sales of fibers and plastics on a year-to-year basis fell 5.2% to $272 million.

One possible explanation for the increasing profits on sales declines comes from Hercules, which suggests that break-even rates at chemical plants are declining. Alexander F. Giacco, chief executive officer, says, "As we move into the fourth quarter, we see no evidence that the recession is ending. However, manufacturing efficiencies have improved to the extent that our break-even point is at about the 55% level."

Giacco is not the only chemical industry executive who does not yet see the end of the recession. Celanese chairman John D. Macomber says, "The demand for Celanese products is closely linked to sales of autos, housing, energy, and apparel. Although we have not yet had any real upturn in any of these sectors of the U.S. economy, we expect these industries and our own businesses to recover gradually in 1983."

NINE-MONTHS 1982			STOCK MARKET DATA							
Change from 1981	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio	Annual indicated dividend	Dividend yield, % of price
				Recent		Recent 12 months				
Earnings	1982	1981	3rd qtr	12 months	Oct. 29	High	Low	Oct. 29		
−17%	2.8%	3.4%	$0.82	$5.20	$ 38½	$41¾	$30	7	$2.40	6.2%
8	6.8	6.1	1.99	7.69	85⅞	86¾	53⅛	11	3.40	4.0
−100	0.0	9.2	−0.88	1.05	18⅞	32¾	16	18	1.00	5.3
15	6.7	6.1	3.10	9.79	106⅛	115¾	73	11	4.20	4.0
−15	10.2	11.9	1.87	6.79	87⅜	98⅛	63¼	13	3.00	3.4
10	4.1	3.6	1.95	6.97	66¾	68⅞	48	10	3.60	5.4
0	3.4	3.4	0.76	2.82	23⅛	24½	16¾	8	1.50	6.5
−6	3.0	3.1	1.20	3.08	29⅜	30⅜	16	10	1.40	4.8
−6	9.5	10.4	1.44	5.46	72¾	76⅝	48	13	3.20	4.4
−31	2.4	3.3	0.89	0.99	20⅜	25	13¼	21	0.60	2.9
−89	0.8	6.5	−0.16	0.72	27¾	31	21⅞	39	1.20	4.3
−21	3.1	3.5	1.47	4.50	39⅞	40⅜	26¾	9	2.22	5.6
21	9.3	8.1	0.91	4.07	71¼	80⅝	44⅝	17	1.84	2.6
−42	3.6	6.6	1.14	3.79	40½	47⅛	22¼	11	1.92	4.7
0	5.0	5.1	0.85	4.02	33⅜	36¼	22	8	1.52	4.6
−13	2.7	3.2	1.63	6.93	65½	66¾	38¾	9	1.84	2.8
−39	4.3	6.8	0.66	2.60	22¾	29¾	16½	9	1.76	7.7
3	13.9	14.1	1.28	5.51	80½	88½	64	15	2.80	3.5
−94	0.4	5.9	1.46	−0.20	13⅝	17	11½	def	0.60	4.4
8	13.9	13.9	1.30	5.46	58⅜	65¼	45⅛	11	2.60	4.5
−11	3.4	3.3	0.64	2.45	28¾	30	17¾	12	0.56	1.9
11	3.5	3.0	1.22	3.04	26⅝	28¼	17⅞	9	1.50	5.6
−8	11.2	12.2	0.53	4.41	17⅝	45⅞	14¼	4	1.00	5.7
−57	1.3	2.5	0.61	0.78	14⅞	18⅜	11¼	19	1.40	9.4
−73	0.9	3.0	0.12	0.30	9¼	9⅞	5⅞	31	0	0
3	9.3	7.5	0.40	11.18	40½	80½	32½	4	4.40	10.9
−25	7.4	9.4	0.66	4.89	50⅝	59⅜	38	10	2.28	4.5
13	4.3	3.9	1.43	6.40	37¾	39¼	27¾	6	2.40	6.4
−70	1.2	4.7	0.45	1.02	21	23⅞	12⅛	21	0.60	2.9
−23	8.5	10.3	1.56	5.57	48	55	38¾	9	2.44	5.1

million gain in first-quarter 1982, and $9.5 million gain in third-quarter 1981; Borden—$2.9 million gain in third-quarter 1982, $10.4 million gain in second-quarter 1982, and $17.6 million gain in first-quarter 1982; Diamond Shamrock—$35.5 million gain in first-quarter 1982; Eli Lilly—$15.2 million charge in third-quarter 1982; Engelhard—$5.2 million charge in second-quarter 1981; General Tire—$3.6 million charge in third-quarter 1982, $4.9 million gain in second-quarter 1982, $30.8 million charge in second-quarter 1982, and $4.4 million charge in first-quarter 1982; NL Industries—$16.6 million charge in third-quarter 1982; Uniroyal—$18.0 million gain in first-quarter 1982. def = deficit.

Gradual recovery, when recovery comes, is the accepted thesis. Dow Chemical president and chief executive officer Paul F. Oreffice says, "The grim economic facts of life persist, and no meaningful signs of recovery are apparent. September rebounded from the traditional weak summer period, but even this gain was not as seasonally expected." Oreffice continues, "Economic conditions are ripe for a business improvement considering the declining trend of inflation and interest rates. However, we need a shift in consumer confidence to spur spending. I don't believe this change will occur overnight; . . . any economic recovery will be gradual."

From Du Pont, whose weak chemical operations have been largely balanced by improvements at Conoco, chairman Edward G. Jefferson concurs on the current state of business. "Although there are still no clear signs of recovery, we believe the recession has bottomed out for most of our traditional businesses. We are continuing our cost-reduction efforts, including a voluntary termination incentive program at our corporate headquarters that will result in a 7% reduction in the professional and managerial staff in the fourth quarter. We anticipate moderate recovery next year in chemical industry volume, and the energy segments are expected to show continued good performance."

A few executives exude a bit more on the coming year. At Goodyear, chairman Charles J. Pilliod Jr. forecasts, "Once the pentup demand is triggered in such interest-sensitive markets as autos, housing, and construction, we can look forward to renewed economic growth, an improved employment picture, and a healthier future both in the U.S. and abroad."

The path to a smoother future, however, has an immediate rocky stretch to negotiate. The chemical industry still has to get through the fourth quarter. To judge from the current market lethargy and the extraordinary pace of one-shot accounting moves such as writeoffs and divestments this year, a lot of bad news may be just ahead. For example, well-managed Vulcan Materials already has warned that its fourth-quarter earnings are expected down more than half from fourth-quarter 1981 after a 25% drop in the third quarter. The company's chemicals could account for more than half the pretax fourth-quarter earnings drop. If Vulcan has such prospects, more-vulnerable firms could too. □

Canadian chemical firms suffer heavy losses

For second quarter in row, combined profits of five major chemical companies were written in red ink; C-I-L was only one to escape

Canadian chemical companies took a financial beating in the third quarter. With sales down on a volume basis, with prices down, and with raw material and operating costs up, perhaps the results were inevitable. But no one suspected that they would be as bad as they were.

The combined results of five major Canadian chemical companies charted by C&EN tell the story in unmistakable terms. The companies are C-I-L, Celanese Canada, Du Pont Canada, Polysar, and Union Carbide Canada.

The combined sales of these companies in the third quarter were just over $1 billion (Canadian dollars used throughout this article), 11.6% lower than they were in the third quarter of 1981. But in the third quarter of 1981, these five companies enjoyed a combined profit of $25.6 million. This year, they lost $24.1 million in the third quarter.

This is the second quarter in a row in which their combined results were written in red ink. In the second quarter, they recorded a loss, but it amounted to only $4.3 million.

The only one of the five major chemical companies to escape the red ink was C-I-L. And it barely made it. Its third-quarter sales were down 13% from last year, but profits plunged 95% to only $600,000.

The company's diverse product line has always been credited with keeping C-I-L's head above water when other companies are floundering. But this time, president and chief executive officer C. H. (Chuck) Hantho says that a severe drop in demand hit across all product lines.

C-I-L's major customers in resource industries have been hard hit by the recession. Many scheduled summer shutdowns were extended to and through the third quarter. The construction industry is operating at low levels and Canada's agricultural sector remains depressed.

Hardest hit of the five major chemical companies was Union Carbide Canada. Compared to the third quarter of 1981, this year's third-quarter sales were down 17.2% (to $168 million), the largest percentage drop of the five firms. To make matters worse, Carbide Canada lost $9.1 million in the third quarter, more than any of the five companies. Even Polysar, with sales 83% higher than Carbide Canada's, lost only $7 million in the third quarter.

Carbide Canada puts much of the blame for its performance squarely on government energy policies that have sharply boosted petrochemical feedstock costs. Meanwhile, the company has had little or no opportunity to recover those costs through higher prices.

Company chairman John S. Dewar notes that the decline in sales was all volume. Prices, he adds, remained unchanged, but costs increased 11%. Petrochemical feedstock costs alone have risen 15% so far this year in Canada, says Dewar, and they have declined as much as 30% in the U.S. This handicap, in the face of severely depressed petrochemical markets, both at home and abroad, helped to generate Carbide Canada's losses.

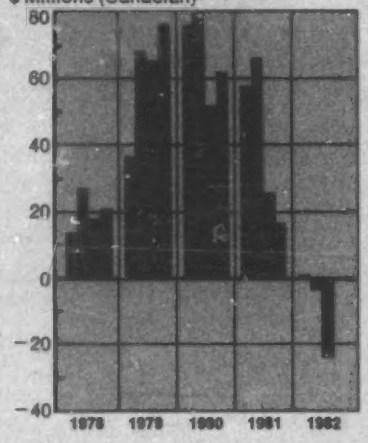
Du Pont Canada, whose sales and earnings were down in the third quarter, points to a tighter and tougher international market as part of the reason. The company's export sales were down 17%, reflecting not only lower overseas demand, but a stronger Canadian dollar against several major foreign currencies.

If there is any optimism to be found among company statements, it is by Celanese Canada. Noting that the third quarter is traditionally the weakest for the company, president and chief executive officer Ernest H. Drew says that the decline this year was not as severe as expected. He detects a significant improvement in September over July and August.

Other executives admit to seeing modest signs of economic recovery in Canada. But most think that the fourth quarter also will be a poor one.

Earl Anderson, New York

Combined earnings dove in the third quarter



a After-tax earnings of five largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, Polysar, and Union Carbide Canada.

Canadian chemical companies ache in the pocketbook

$ Millions (Canadian)	Net sales	Change from 1981	Net income[a]	Change from 1981	Profit margin[b] 1982	Profit margin[b] 1981
	NINE-MONTHS 1982					
C-I-L Inc.	$ 826.8	−6.3%	$17.3	−61.6%	2.1%	5.1%
Celanese Canada	230.8	−16.3	−5.9	def	def	6.3
Du Pont Canada	748.4	−14.2	−6.9	def	def	4.1
Polysar Ltd.	1012.6	0.1	−17.3	def	def	1.8
Union Carbide Canada	524.7	−15.8	−14.9	def	def	5.4
TOTAL	$3343.3	−6.8%	−$27.7	def	def	4.1%

a Net income from continuing operations, excluding extraordinary gains or losses. b Net income as a percentage of sales. def = deficit.

Biomaterials poised for major advances

Conference held by National Institutes of Health surveys status of field, proposes ways to help it achieve its potential in therapeutics

Richard J. Seltzer
C&EN, Washington

Suppose one asked an average television viewer what pops into mind when he or she hears the word "biomaterials"—substances used to replace, augment, or treat parts of the body? "The Bionic Man," "The $6 Million Man," or "The Bionic Woman" would be the response, more likely than not. How could a viewer not be intrigued and impressed by the concept of superhuman capacities created by replacement of body parts with synthetic ones—at a cost of $6 million for the bionic man?

Science fiction is far ahead of science in this case, as in so many others. But even without such heroics, progress in biomaterials has been dramatic in recent years. Indeed, says Pierre M. Galletti, vice president and professor of biology and medicine at Brown University, biomaterials "underlie what I consider the major revolution in therapeutics and in medicine in the second half of the 20th century." Biomaterials are already being used on "an extremely large scale," resulting in greatly improved patient care, he points out.

Yet, the emerging technology of biomaterials is only in its infancy, and its uses and potential uses are, by and large, not appreciated by the medical world and the public, Galletti believes. Significant improvements are needed in basic materials for current uses, and to enable preparation of more sophisticated medical devices to perform more complex tasks. And there is a whole host of questions surrounding biomaterials—technological, scientific, medical, economic, regulatory, legal, and social—that need to be addressed.

To bring the best available thinking to bear on these questions and to try to move the whole field forward, the National Institutes of Health earlier this month convened a consensus development conference in Bethesda, Md., on clinical applications of biomaterials. Bringing together some 350 physicians, dentists, polymer scientists, surface chemists, biochemists, materials scientists, metallurgists, chemical and biomedical engineers, mechanical engineers, microbiologists, business executives, lawyers, government officials, and consumers, the three-day conference was sponsored by the Biomedical Engineering & Instrumentation Branch of NIH's Division of Research Services. About 40% of the participants were from industry and 60% from the medical world, academia, and government.

C&EN staff photo

Galletti: major revolution in medicine

Galletti chaired a consensus development panel of 16 members from a variety of backgrounds—including industrial and academic research on materials, incorporation of materials into medical devices, product development, quality control, marketing of medical devices, clinical use, receipt of medical devices as a consumer, and legal representation regarding medical devices. The panel focused on five key questions:

- How safe and effective are biomaterials currently in clinical use?
- How well can we predict biological performance of materials in the human body: host response, biomaterials response?
- What results of ongoing research in materials science would be potentially applicable to clinical care?
- Are the ways for introducing biomaterials into medical use responsive to current clinical needs? Which elements in the process are amenable to improvements?
- What are the areas of greatest clinical need for new biomaterials?

Biomaterials already used on vast scale in U.S.

Number applications per year	
Cardiovascular implants	
Heart valves	30,000
Pacemakers	100,000
Vascular grafts	50,000–150,000
Dental implants	10,000–20,000
Plastic and reconstructive implants	
Breast prostheses	100,000
Cosmetic	78,000
After mastectomy	22,000
Nose, chin, other prostheses	10,000
Penile prostheses	5,000
Ophthalmic implants	
Lenses	250,000
Retinal surgery	25,000–50,000
Other prostheses	7,000–8,000
Orthopedic prostheses	
Hips	110,000
Knees	65,000
Shoulders, finger joints, other areas	50,000
Neurosurgical implants	
Ventricular shunts	21,500
Extracorporeal devices	
Oxygenators	196,000
For coronary bypass procedures	150,000
Renal dialyzers	6,200,000

Source: Collected by Arthur C. Beall Jr. of Baylor College of Medicine from multiple sources and his own estimates

Consensus conferences assess medical technologies

Are some widely used medical technologies unsafe or ineffective? Are there other, less widely used technologies that are safe and effective and should be used more? How can the scientific community reach generally accepted answers to questions of technology assessment? And how can the scientific community improve translation of the results of biomedical research into medical practice?

Concerned about these questions and the lack of any formal mechanism to deal with them, the National Institutes of Health in 1977 started a program of consensus development conferences. These conferences—such as one held earlier this month on clinical applications of biomaterials—bring together research scientists, practicing physicians, consumers, and others for three days of intensive discussions focusing on a device, drug, or medical, surgical, or dental procedure that may be either new or already in general use.

The central element in the consensus process is a panel that includes a wide range of scientific and medical experts in fields relevant to the technology—including lawyers and other specialists where legal, social, or economic considerations are involved. (No federal officials serve on the panels.) The panel focuses on a specific set of questions regarding the technology. It listens to a series of lectures from experts, and to discussion and suggestions from the audience, since the conferences are open to all points of view.

The panel then seeks to reach a consensus among its members, and to issue a written report containing recommendations framed around the original questions and representing the best current thinking on the subject. The audience may suggest changes in the draft consensus report before it becomes final.

So far, 34 consensus development conferences have been held. They have covered such topics as breast cancer screening, estrogen use and postmenopausal women, adjuvant chemotherapy of breast cancer, carcinoembryonic antigen as a cancer marker, and computed tomographic scanning of the brain.

In some instances, the reports identify safe and useful new medical technologies and make a wider audience aware of their potential. In other cases, they find that a technology has not been validated adequately or point out problems a technology may cause, even recommending against using a technology under certain conditions. The consensus reports are published by the Government Printing Office and are disseminated to scientists, physicians, the public, and the media in the U.S. and abroad.

Speakers at the conference presented several definitions of biomaterials, but the consensus statement adopted by the panel defines biomaterials as "any substance (not a drug) or combination of substances, synthetic or natural in origin, which can be used for any period of time, as a whole or as a part of a system which treats, augments, or replaces any tissue, organ, or function of the body." This definition excludes some things, such as organ transplants. However, it is so broad that it embraces hearing aids, eyeglasses, renal dialysis machines, or, indeed, intravenous needles. Nevertheless, the bulk of the conference's attention focused on implants and prostheses used for long periods of time in the body.

Since the early 1950s, devices made with biomaterials have been introduced into the human body at an ever-increasing rate. Initially, use focused on life-threatening situations, but it since has expanded to treat or support a wide range of bodily functions for rehabilitation, comfort, convenience, and esthetics.

Similarly, "implant medicine" originally was viewed as a therapeutic approach in end-stage disease. However, it is now moving in the direction of restoration of chronically damaged structures, and some day may be able to carry out preventive maintenance in early stages of disease.

It is difficult to put exact figures on the magnitude of current use, but the consensus report says that several million biomaterial implants probably occur each year in the U.S. alone. Arthur C. Beall Jr. of Baylor College of Medicine cites estimates of some 100,000 pacemaker implants, 100,000 breast prostheses, and 110,000 hip prostheses.

In general, the consensus report finds currently used biomaterials safe and effective, with some variations. Little difficulty occurs from local tissue reaction or systemic toxicity. Some reports of immune responses are stimulating efforts to find less sensitizing materials. No apparent evidence exists of carcinogenic response. Few of these factors have been evaluated over extended periods of time, however, and the report recommends increased study to establish long-term safety.

As to the devices in which biomaterials are used, they are generally safe and effective, although significant improvements can be made. For example, hip replacements are much more successful than prostheses for other joints.

However, biological performance of materials in the body in terms of host response and biomaterials response can't be predicted very well at present. Researchers are only starting to study the science involved, and application has been largely empirical. Fundamental knowledge is limited on host responses and the effects of host tissues on materials. Surface and bulk properties may differ for a biomaterial, yielding variations in host and material responses. And biomechanical data is lacking for living tissues.

The consensus report notes that there is "a definite gap" between progress in materials science research and use of materials in biomedical applications. "The field of biomaterials is first and foremost a materials science," the report says. To date, notes Richard E. Clark of Washington University, St. Louis, practically no material used in an implantable device has been designed from the molecule up to meet specific long-term, in vivo conditions. Instead, most of the biomaterials have been off-the-shelf materials developed for nonmedical uses. And even there, says Galletti, only a handful of materials has been exploited for clinical use, and many others should be looked at.

The report points to several areas where materials science is mature enough to enable scientists to design specific biomaterials to provide improved host and biomaterial response to medical devices. In particular, Galletti says polymer chemistry, which he calls "the basic science of biomaterials," is on the verge of some very significant conceptual advances. Much as structure-activity relationships were developed for drugs a generation ago, scientists are now in a position to anticipate biological activities from a knowledge of the chemical structures of several polymers, he explains.

The report notes that new polyurethane elastomers, about to be introduced to clinical use, are expected to have a positive impact on cardiovascular devices.

Another promising area, points out Robert S. Langer of Massachusetts

Institute of Technology, is development of polymeric systems for controlled release of conventional and macromolecular drugs. Developing the use of bioerodible polymers for long-term delivery of macromolecular drugs is of particular interest, he adds, because the implants eventually would be absorbed and would not need to be removed. On the horizon is a whole new arsenal of potent macromolecular drugs with short half lives that would need such delivery systems—for example, growth hormones, endorphins, enkephalins, interferon, and luteinizing hormone-releasing hormone.

Another area of high potential is composites, for instance, polymeric composites for blood-contacting devices, and polymer-carbon structural composites for musculoskeletal augmentation. Composites in which one or more phases are absorbable offer promise for applications where healing processes gradually can replace the implant with natural tissue.

As for metal biomaterials, the report suggests exploring new processing techniques that maximize mechanical properties of current alloys, such as hot isostatic pressing and powder metallurgy. Coating processes—for instance, reactive flame spraying, carbon coating, and nitriding—are another possibility for reducing corrosion and thus reducing local and systemic host response. And in another area, according to Klaas de Groot of the Free University of Amsterdam, the Netherlands, bioceramics—based on calcium phosphate salts, mostly calcium apatite and calcium whitlockite—are on the verge of being applied to clinical practice to replace or reconstruct bone.

Areas of greatest clinical need for new biomaterials are listed in the report. Among them are materials that could duplicate the physical and biological properties of various body parts, and hence replace skin, muscles, tendons, and other native tissues; elastomers to replace body components that undergo repeated bending; and materials that can be implanted within the cardiovascular system without risk of blood clot formation.

The report notes in its conclusion that "the biomaterials field is in transition from a cottage industry to an integrated research and product development effort." As several participants observed, biomaterials is having trouble organizing itself as a discipline. There is as yet no uniform set of principles in biomaterials research, with each participating discipline applying its own precepts in an empirical fashion. Thus, an interdisciplinary approach—assembling a critical mass of investigators—is needed. □

New route produces ethylene from synthesis gas

A new entry in direct synthesis of olefins is a process under development at Texaco Chemical Co. for making ethylene from synthesis gas. A two-stage process, it relies on a ruthenium-based catalyst.

Ever since the Fischer-Tropsch synthesis was recognized as primarily an olefin producer, it has been a potential source of ethylene and propylene. But so have methanol homologation and subsequent dehydration, methanol cracking, and the direct synthesis of olefins from synthesis gas.

One or more processes in each of these areas has been suggested, but none has yet reached commercial success.

A number of assessments have leaned toward direct syntheses as being front-runners. One of the arguments in their favor is that the 50% carbon selectivity to olefins that is needed to make the processes competitive with paraffin pyrolysis appears to be achievable by the end of the 1980s.

Texaco research chemist John F. Knifton describes the company's approach: a two-stage process for making ethylene-rich olefins, ethanol, and ethyl esters of aliphatic carboxylic acids. The first stage involves hydrogenation of carbon monoxide to an ethyl ester in the presence of an aliphatic carboxylic acid. The catalyst is a soluble ruthenium species modified with quaternary, group 5A salts. A typical example would be RuO_2-H_2O-$[(C_6H_5)_4PBr]$. In the second stage the intermediate ethyl ester may be either pyrolyzed to yield ethylene or hydrolyzed to ethanol.

Knifton believes that the selective synthesis of ethyl esters from synthesis gas and the corresponding aliphatic carboxylic acid is novel. The thermodynamics, he says, are favorable for ethyl ester production, and the equilibrium constant exhibits high sensitivity to temperature.

At least 14 catalyst combinations have been tried. All are more or less productive over a broad range of process conditions, and the highest conversion to esters has been about 94%. The highest catalyst turnover number has been 5.7×10^{-3} sec^{-1}.

The esters formed and the residual ruthenium catalysts are recycled easily. Knifton says that the process appears to be strictly homogeneous since no hydrocarbons higher than methane are formed. There is no evidence for the plating out of ruthenium, and the catalyst does not deactivate with recycle.

Knifton makes several suggestions for mechanisms. Direct ethanol production is ruled out, as is the route via homologation of methanol. The most likely sequences appear to be

$$CO/H_2 \xrightarrow{RCOOH} RCOOCH_3$$

$$\xrightarrow{CO/H_2} RCOOCH_2CH_3$$

and

$$CO/H_2 \rightarrow CH_3OH \xrightarrow{RCOOH}$$

$$RCOOCH_3 \xrightarrow{CO/H_2} RCOOCH_2CH_3$$

with the former reaction being the most probable. The second stage also has been demonstrated for ester intermediates.

Most of Texaco's interest seems to be in the pyrolysis of the propionates to ethylene, propylene, and propionic acid in the gas phase. The development work is being continued, Knifton says. □

Ethylene process uses ruthenium catalyst